Indicator: Ecological Framework (308R)

Ecosystems function naturally to provide clean air through the removal of particulate matter and storage of carbon, clean water through the assimilation of nutrients and sediment reduction, and better protected lands that can control flood waters and maintain biological diversity. These services that enhance the quality of life depend on an *ecological framework* of high-quality land consisting of central hubs interconnected by corridors that provide for the movement of energy, matter, and species across the landscape. This framework is threatened by agricultural, silvicultural, and road development practices and “urban sprawl” that are fragmenting the landscape and threatening this ecological framework.

This Ecological Framework (EF) indicator is inclusive of five sub-indicators that contribute to the necessary ecological infrastructure of Region 4 (http://geoplan.ufl.edu/epa/download/sef_report.pdf). Hub and Corridor Connectivity shows the location of critical ecosystems in the southeast region of the United States. Potential Land Use Change shows those areas of the EF that are most likely to be fragmented based on an urban growth model that uses distance to roads and existing urban areas to identify potential areas of growth. The Biodiversity Index is comprised of nine data layers associated with levels of species diversity (all of the EF is important to biodiversity for the region, but some locations have higher ratings because they satisfy multiple criteria important to biodiversity). The Ecosystem Services Index is developed from seven data layers related to direct or indirect services provided by functioning ecological systems (including priority groundwater and surface water areas, proximity to shellfish harvesting, potential for storm water protection and other water resource protection data). Riparian corridors within the EF show a particularly high propensity for providing services due to their proximity to water. Gross Primary Productivity (GPP) captures the fixation of carbon in the landscape based on 1 kilometer data derived from MODIS (MOD17) satellite data. The EF indicator provides a baseline for the period 1992-93.

What the Data Show

The Ecological Framework (EF) Hub and Corridor Connectivity indicator covers 43% of the available land and water resources in the Region. A total of 61% of the EF consists of hubs and 39% consists of corridors associated with the EF (Figure 308R-1). Currently, 22% of the EF is protected, 12% is in the public domain as open water, and 14% is classified as wetlands for a total of 48% of the Ecological Framework being afforded some type of long-term protection.

The Ecological Framework (EF) Potential Land Use Change indicator shows that 65% of the EF area has a low potential of fragmentation; 22% are at moderate risk of fragmentation, and 9% are at high risk of fragmentation (Figure 308R-2). The remaining 4% of the EF was identified as having no potential for development because the areas were so far removed from current development patterns. The red areas identified in the figure are the most likely to be fragmented as a result of the outward expansion of urban development.

The Ecological Framework (EF) Biodiversity Index shows that the area with the lowest scores (1 to 3) in the normalized index comprise 20% of the EF, 38% of the area scored between 4 to 7, and 43% of the EF scored 8 to 10 (Figure 308R-3).

The Ecological Framework (EF) Ecosystem Services Index shows 25% of the area in the EF to have the lowest scores (1-3); 39% of the area to have scores of 4-7; and 35% to have the highest scores of 8-10 (Figure 308R-4). The total does not equal 100% due to rounding errors.

The Ecological Framework (EF) Gross Primary Productivity (GPP) indicator shows that 5% of the EF that is represented by GPP of less than $1000m^2$; 80% falls between $1000gm/m^2/yr$ and $2000\ gm/m^2/yr$;

and the remaining 15% has a GPP greater than 2000gm/m2/yr (Figure 308R-5). The highly productive areas are coastal wetlands. The total GPP of the EF was calculated to be 697 million tons of carbon per year (Ajtay 1979 and Milesi 2003).

Indicator limitations

- The most important data layer used in the EF indicator suite is the National Land Cover Data (NLCD), which date from 1992-93.

Data Sources

The data supporting this indicator can be found at:
http://geoplan.ufl.edu/epa/index.html
http://landcover.usgs.gov/natllandcover.asp
http://ntsg.umt.edu/default.htm

References

Ajtay, L.L., Ketner, P., and Duvigneaud, P. 1979. Terrestrial production and phytomass. In Bolin, B., Degens, E.T., Kempe, S., and Ketner, P. (eds), The Global Carbon C SCOPE Report No. 13, 129-181, John Wiley and Sons, NY

Milesi, C., Elvidge C., Nemani, R., and Running, S. 2003. "Assessing the impact of urban land development on net primary productivity in the southeastern United States." Remote Sensing of Environment 86: 401-410.

Graphics

Figure 308R-1

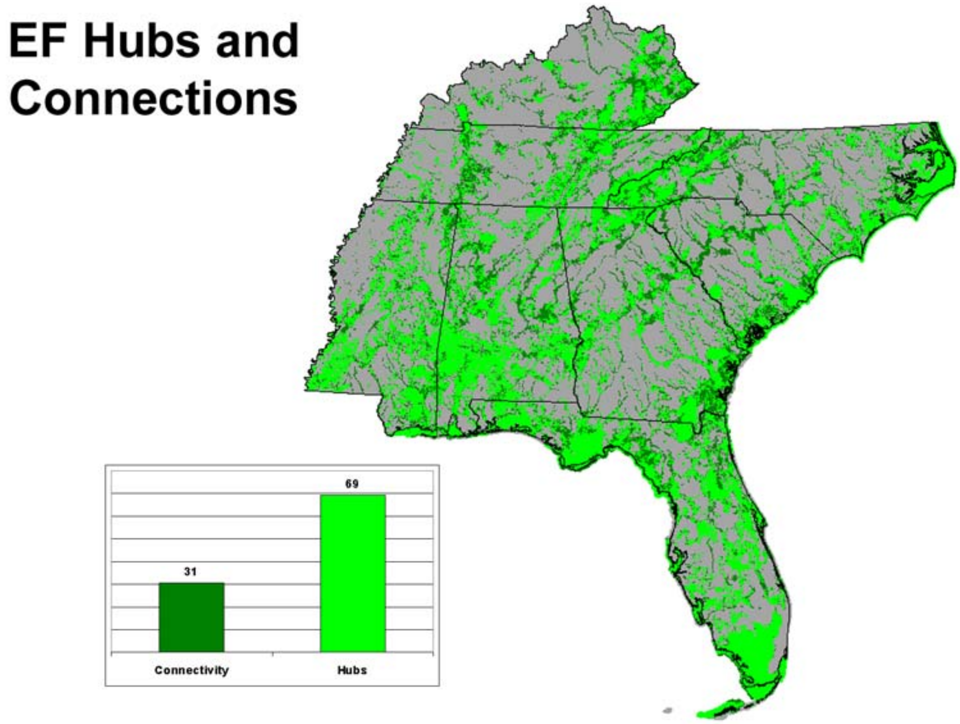


Figure 308R-2

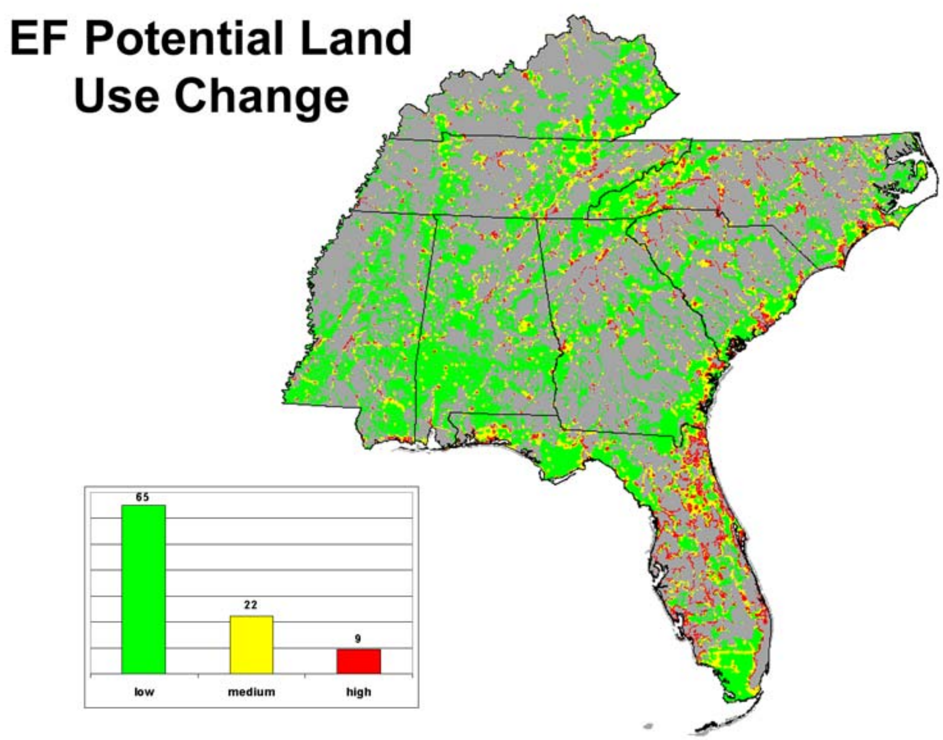


Figure 308R-3

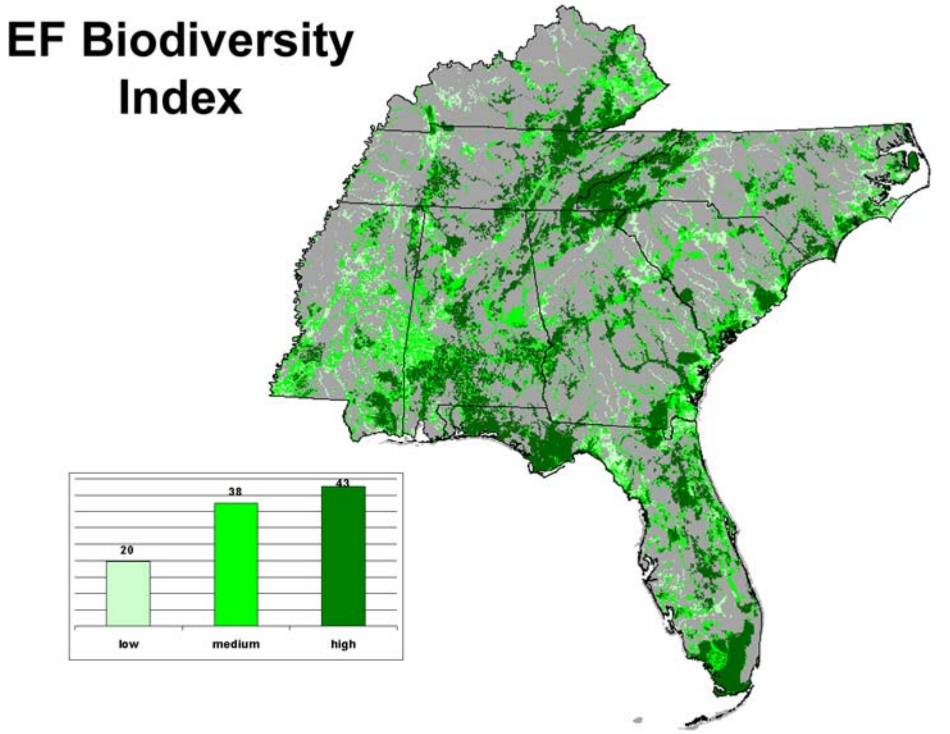


Figure 308R-4

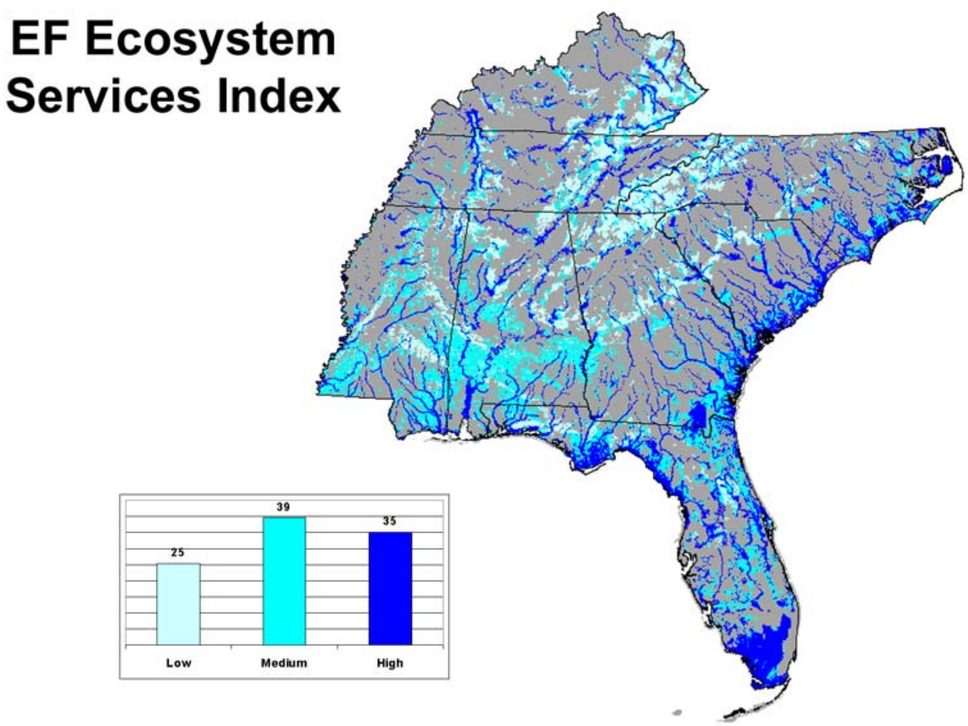
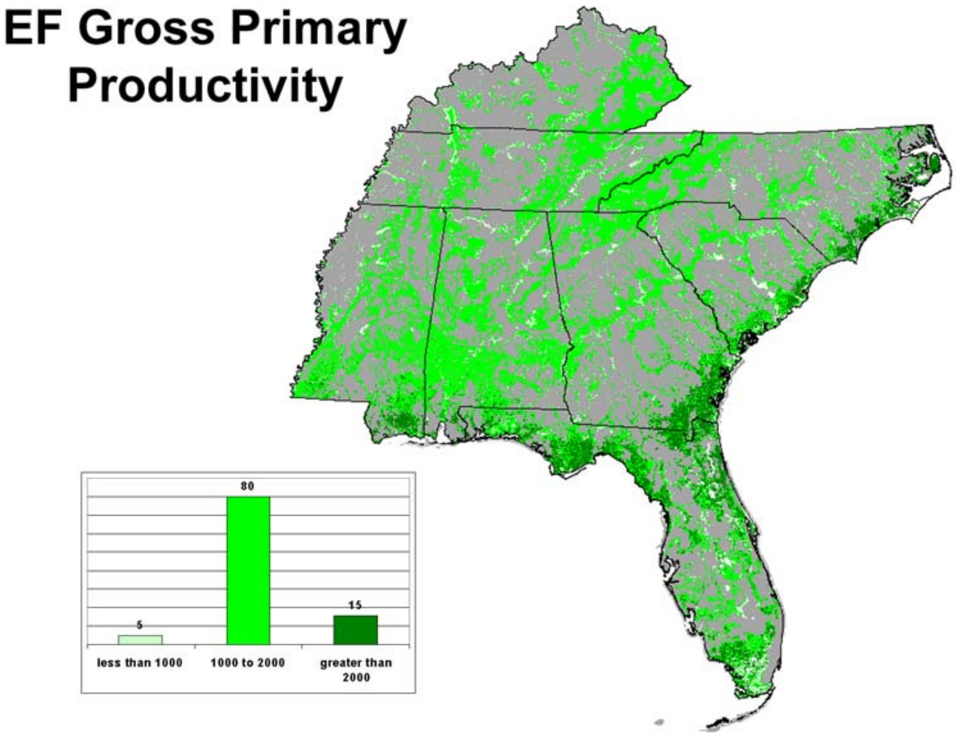


Figure 308R-5



R.O.E. Indicator QA/QC

Data Set Name: ECOLOGICAL FRAMEWORK
Indicator Number: 113290 (113290)
Data Set Source: Primary data source is the National Land Cover Data
Data Collection Date: ongoing: 1992 - present
Data Collection Frequency: landcover obtained every 8 years
Data Set Description: Ecological Connectivity identifies an ecological prespective of important landscapes across the southeast. Landscape ecologists have known for a long time that piece-meal protection of the environment often leads to degradation of the parts being protected. The resulting fragmentation prevents the operation of many large-scale processes from adequately functioning to protect the land, air and water quality of the region. Environmental protection of these critical ecosystems and their connectivity with other natural areas is an important principle for the long-term health of the Southeast.
Primary ROE Question: What are the trends in the extent and distribution of the Nation's ecological systems?
Comment: The challenges of the new century will be focused on how human actions impact ecosystem function. To address these challenges, EPA will need to address the greatest threats to ecosystem function from natural landscape fragmentation resulting from current population and economic development trends. Roads, agriculture, and sprawl, represent the most prevalent changes in our natural landscape and cause natural systems to become divided into isolated parts. Research shows that landscapes lose their ecological integrity with increasing fragmentation, which can include the loss of biological diversity, the degradation of water quality and the loss of other important ecological services. Many natural ecosystem

types in the southeast have suffered significant losses and degradation. Longleaf pine forests, bottomland hardwoods and wetlands have lost 98%, 78% and 28% percent respectively of their pre-settlement extent in this region. In addition, many acres of remaining forests have been modified and are in plantation forestry, leaving even smaller, sometimes-isolated areas to preserve native habitat and ecosystem function. These dwindling natural systems are falling under increased pressure to support a growing human population. By identifying a large-scale connected framework, it is possible to provide a foundation in which protection of the ecological properties and processes can be optimized in support of EPA's goals and objectives for benefits at the local and regional scale. Of the remaining natural areas in the region, not all are equal in their support of ecosystem services. Critical areas may include wetlands located up stream of drinking water intakes. Other critical areas may be identified as flood protection for a small farming town or riparian buffers to eliminate the need of a sediment filtration system. There are also many areas that have high ecological integrity or high biological diversity, have critical roles in watershed protection, or can provide the only possible linkages between other existing natural areas.

Question/Response

T1Q1 Are the physical, chemical, or biological measurements upon which this indicator is based widely accepted as scientifically and technically valid?

Trends in conservation are leading to integrative, comprehensive approaches to natural resource conservation. Related concepts that are now being forwarded include Ecological Networks, Regional Conservation Planning, Green Infrastructure Planning and Wildland Reserve Networks many organizations such as the World Wildlife Fund, The Nature Conservancy, and the Trust for Public Land are attempting to use geographical information system tools for identifying hot spots, priority areas, or the last great remaining places. A significant problem with any approach is identifying the appropriate scale to evaluate natural resources, the amount and consistency of data available and stakeholder involvement or local ownership of the final product. Each aspect has significant hurdles to overcome and often leaves room for improvement on any product eventually developed. In 1995, the Southern Appalachian Man and Biosphere (SAMAB) Cooperative completed the Southern Appalachian Assessment (SAA) through the collaborative efforts of federal agencies, state agencies, universities, special interest groups, and private citizens. The effort was an attempt to evaluate the living systems of the Southern Appalachian Region - the animals, the plants, and the land, air, and water that support them - and the enormous changes that have taken place during the 20th century. This marked the first attempt at developing a consistent data set for evaluating natural resources and received the Hammer Award. The SAA, however, fell short in providing useful information for local decision makers. One problem was due in large part to the complexity of the GIS tools available at the time and little training by municipal officials in the technology. A second significant problem with the SAA was that the majority of data was developed to identify trends at a county level and provided little opportunity for understanding landscape changes within a county. Although point data and land use coverage were included in the final SAA, further difficulty lied in the fact that no analysis of the relationship of one data set with another was developed to give a firm indication of what land may be at risk from existing or potential growth in the future.

T1Q2 Is the sampling design and/or monitoring plan used to collect the data over time and space based on sound scientific principles?

Three steps were involved in the design of the Ecological Framework. The first included the identification of priority and significant ecological areas. The second focused on identifying the ecological hubs. The third involved the delineation of landscape linkages across the landscape and between the hubs. The identification of the Ecological Framework involved four primary steps. First, in what can be termed the inventory phase, all relevant available Geographical Information System (GIS) data were collected, including regional, sub-regional, and state data layers. These GIS data were then assessed to determine areas of ecological conservation significance called Priority Ecological Areas and Significant Ecological Areas as well as landuse and landscape features that could impact ecological integrity. Second, the largest intact areas of ecological significance (Hubs) were delineated. Third, a GIS model was developed to identify the best opportunities to maintain ecological connectedness (Corridors) between selected Hubs. Finally, all framework components were integrated and optimized to create the Ecological Framework.

T1Q3 Is the conceptual model used to transform these measurements into an indicator widely accepted as a scientifically sound representation of the phenomenon it indicates?

The Ecological Framework was developed based on the University of Florida's experience in creating the Florida Ecological Network (FEN) for the State of Florida. Following the work of Harris, Noss and other ecologists, the state adopted the concept of an integrated habitat network as part of the Florida Greenways Program in 1992. Although greenways are often associated with linear recreational features such as rails-to-trails, the Florida concept was to include wildlife corridors, landscape linkages, and landscape-level conservation areas within an ecological network connecting public and private conservation lands across the state. As part of the process to develop a statewide greenways plan, the University of Florida developed a spatial analysis model to help identify the best opportunities to protect ecological connectivity statewide. GIS software was used to analyze all of the best available data on land use and significant ecological areas including important habitats for native species, important natural communities, wetlands, road less areas, floodplains, and important aquatic ecosystems. This information was then integrated in a process that identified the FEN containing all of the largest areas of ecological and natural resource significance and the landscape linkages necessary to protect a functional statewide network. The process was collaborative and overseen by three separate state-appointed greenways councils. During the development of the model, technical input was obtained from the Florida Greenways Commission, the Florida Greenways Coordinating Council, other state, regional and federal agencies, scientists, university personnel, conservation groups, planners and the general public in over 20 sessions. When the modeling was completed, the results were thoroughly reviewed in public meetings statewide as part of the development of the Greenways Implementation Plan completed in 1999, and the work was published in Conservation Biology, in August, 2000 (Hoctor et al. 2000). The FEN delineation process combined a systematic landscape analysis of ecological significance and the identification of critical landscape linkages in a way that could be replicated, enhanced with new data, and applied at different scales. The FEN connects and integrates existing conservation areas with unprotected areas of high ecological significance. This information can be used in concert with other information on conservation priorities to develop a more integrated landscape protection strategy.

T2Q1 To what extent is the indicator sampling design and monitoring plan appropriate for answering the relevant question in the ROE?

The modeling process utilized in both the FEN and the EF has important strengths that facilitate its ability to serve as an indicator for different regions or scales. The process combines a systematic landscape analysis of ecological significance, large intact landscapes, and opportunities for ecological connectivity in a way that can be replicated, enhanced with new data, and applied at different scales. The identification of Priority Ecological Areas and corridors is query-based, which allows great flexibility in model inputs and decision-making processes. Without relying on complex weighting schemes, the modeling process can be adapted to various situations with different objectives and data sources. Criteria, thresholds, and the scale of the analysis can easily be changed, which can either be used to modify the existing model results or to re-run the model as resources allow. This affords the opportunity to develop the model process for other regions and allows for iterative identification processes as new data becomes available. The model can also be applied from local to regional scales, and local versions of the modeling process can be created using even more resolute and specific data sets to assist in connecting local conservation planning initiatives with larger scale ecological processes. In addition, ever-increasing sophistication of computer technology is allowing for large regional assessments to be done using more resolute data and analyses.

T2Q2 To what extent does the sampling design represent sensitive populations or ecosystems?

The Ecological Framework incorporates all large conservation lands, large wetland basins and intact riparian areas around all major rivers, all major forested roadless areas, and other intact areas of ecological significance throughout Region 4. Approximately 98% of existing conservation lands in Region 4 is incorporated within the EF. The EF also contains 77% of the wetlands and 56% of all forested lands within the region. Coincidentally only about 2% of the EF is comprised of agricultural lands (pastures or croplands) and only approximately 2% of the agricultural lands in the southeast 4 are found within the EF. The agricultural lands that do occur within the EF are either within the boundaries of conservation areas or were added as part of landscape linkages in some cases, particularly within the ranchlands of south-central Florida and in some linkages along the fall line along the Piedmont and coastal plain boundary.

T2Q3 Are there established reference points, thresholds or ranges of values for this indicator that unambiguously reflect the state of the environment?

Hubs represent the Priority Ecological Areas after the exclusion process that are also 5,000 acres or larger. These represent larger intact areas that can serve as the building blocks for local to regional networks of protected lands. In this model Hubs became the focal step of the linkage process, where all opportunities to protect existing or restore connectivity between Hubs was assessed. There are still many areas within Region 4 that meet the criteria for being ecological Hubs with 28% of the region within Hubs. Hubs were then optimized spatially to fill gaps that contained suitable land cover and create more intact edges wherever possible. Optimized Hubs add slightly more acreage and incorporate 30% of Region 4. The linkage portion of the model is then run to identify the best opportunities for physical ecological connections between appropriate Hubs. Linkage types include: 1. Riparian linkages including all major river systems and coastal water bodies such as lagoons and connected estuaries. 2. Upland linkages were used primarily in mountain and plateau ecoregions. 3. General Hub-to-Hub linkages consider wetlands and uplands as potentially suitable and were used primarily in the Coastal Plain and Piedmont ecoregions. Landscape Linkages are identified with an AML-based user interface in Arc-Info. The least cost path function, which can be used to identify the lowest cost, or conversely, the most suitable path between destinations was the primary algorithm used in the interface. Cost surfaces were created for each linkage type, where most appropriate landscape features for supporting a landscape linkage are given the lowest number and the least suitable landscape features are assigned the highest number. Landscape linkages are then identified using a process where hub pairs are selected for potential connection, resulting least cost paths are examined, and accepted least cost paths are buffered based on the length of the linkage and the characteristics of the particular landscape. After buffering least cost paths, all linkages are "smoothed" using an algorithm that deletes outlier cells. The upland linkages are also optimized by adding Category II (agricultural) land uses within 500 meters of the least cost path. The values in the cost surface represent the resistance to going through an individual cell. As an example, the path would go through 99 cells valued as 1 instead of going through a single cell valued as 100. All three cost surfaces include the identification of large blocks of intact natural or semi-natural vegetation to help locate landscape linkages in wide, intact areas instead of narrow corridors whenever possible. These intact areas are separated into two classes: large and moderate. Large intact areas are defined as natural and semi-natural vegetation within both a 590 hectare area and 65 hectare area containing 90% or more natural or semi-natural vegetation in blocks 5000 acres or larger and without primary roads. Moderate intact areas are defined as natural and semi-natural vegetation within both a 590 hectare area and 65 hectare area containing 90% or more natural or semi-natural vegetation in blocks 1000 acres or larger and without primary roads.

T3Q1 What documentation clearly and completely describes the underlying sampling and analytical procedures used?

Final Report: Southeastern Ecological Framework; www.geoplan.ufl.edu/epa/download/sef_report.pdf; May 2002; Hoctor, et al. Review of the Southeastern Ecological Framework: An EPA Science Advisory Board Report; http://www.epa.gov/science1/pdf/epecl02002.pdf; June 2002; Glaze, Young and Dale.

T3Q2 Is the complete data set accessible, including metadata, data-dictionaries and embedded definitions or are there confidentiality issues that may limit accessibility to the complete data set?

Yes, there is a complete data set available. www.geoplan.ufl.edu/epa or contact Dr. John Richardson; richardson.john@epa.gov; 404-562-8290

T3Q3 Are the descriptions of the study or survey design clear, complete and sufficient to enable the study or survey to be reproduced?
Yes

T3Q4 To what extent are the procedures for quality assurance and quality control of the data documented and accessible?

Final Report: Southeastern Ecological Framework; www.geoplan.ufl.edu/epa/download/sef_report.pdf; May 2002; Hoctor, et al.

T4Q1 Have appropriate statistical methods been used to generalize or portray data beyond the time or spatial locations where measurements were made (e.g., statistical survey inference, no generalization is possible)?

No.

T4Q2 Are uncertainty measurements or estimates available for the indicator and/or the underlying data set?

Yes, the accuracy of the 1992 NLCD land-cover map was conducted by EPA federal region (see figure) using a probability sampling design incorporating three levels of stratification and two stages of selection. Details of the methodology and results have been published. Although some regional variation in protocol and implementation exists, all of the regions shared a common general framework. The goals of this framework were to insure that: 1) satisfy protocols defining a probability sample; 2) sufficient sample sizes were acquired for each land-cover class; 3) reasonable cost controls were maintained and 4) a spatially well-distributed sample was acquired. Reference land-cover labels were acquired through the photo-interpretation of NAPP aerial photographs, or DOQQs. A correct classification was defined as occurring when the primary or secondary reference label matched the mode class present in a 3x3 block centered on the sample point. Assessments were conducted at both the Anderson level I and II levels of classification. In addition to the above accuracy reports, research has been conducted in evaluating different sampling schemes, as well as the impact of landscape characteristics on accuracy.

T4Q3 Do the uncertainty and variability impact the conclusions that can be inferred from the data and the utility of the indicator?

Not really, since we are looking at a regional or broad scale. However, scale can certainly impair conclusions in trying to utilize the information contained in the ecosystem connectivity indicator when attempting to draw conclusions at a local level.

T4Q4 re there limitations, or gaps in the data that may mislead a user about fundamental trends in the indicator over space or time period for which data are available?

No. The limitations are related to the completion of the NLCD for 2000 from which comparisons can be drawn.